CS15210: Multiplexors and Switching

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(based on slides by Mike Clarke)

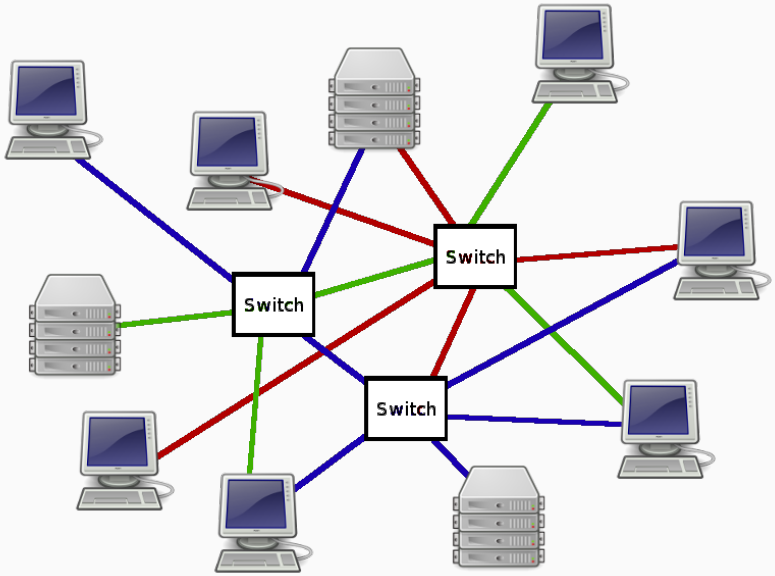
Previously, in CS15210...

- The PSTN, ADSL
- Bandwidth vs Channel Capacity:
  - Bandwidth: the range of frequencies
  - Channel capacity: number of bits per second
- Equations for maximum channel capacity:
  - Nyquist's Theorem: regardless of noise
  - Shannon-Hartley Theorem: regardless of signalling levels

Contents

Basic Network Terminology

All nodes on a network can be divided into:



- **Switches**: control and direct the network traffic
- **Clients**: used directly by users of the network;

  hardware (e.g. your PC), software (e.g. your browser)
- **Servers**: provide services to the clients

  (e.g. a file store, a database, printing, web pages)

Basic Network Terminology

- Local Area Networks (LANs)
  - Cover a single site or several sites very close to each other
  - They are usually privately owned and belong to one organisation
  - e.g. AU's network
- Wide Area Networks (WANs)
  - Connect sites that are further away from each other – possibly just a few miles, possibly the other side of the world
  - The physical infrastructure (cables, microwave links, satellite links) is usually provided by a separate supplier
  - e.g. Janet

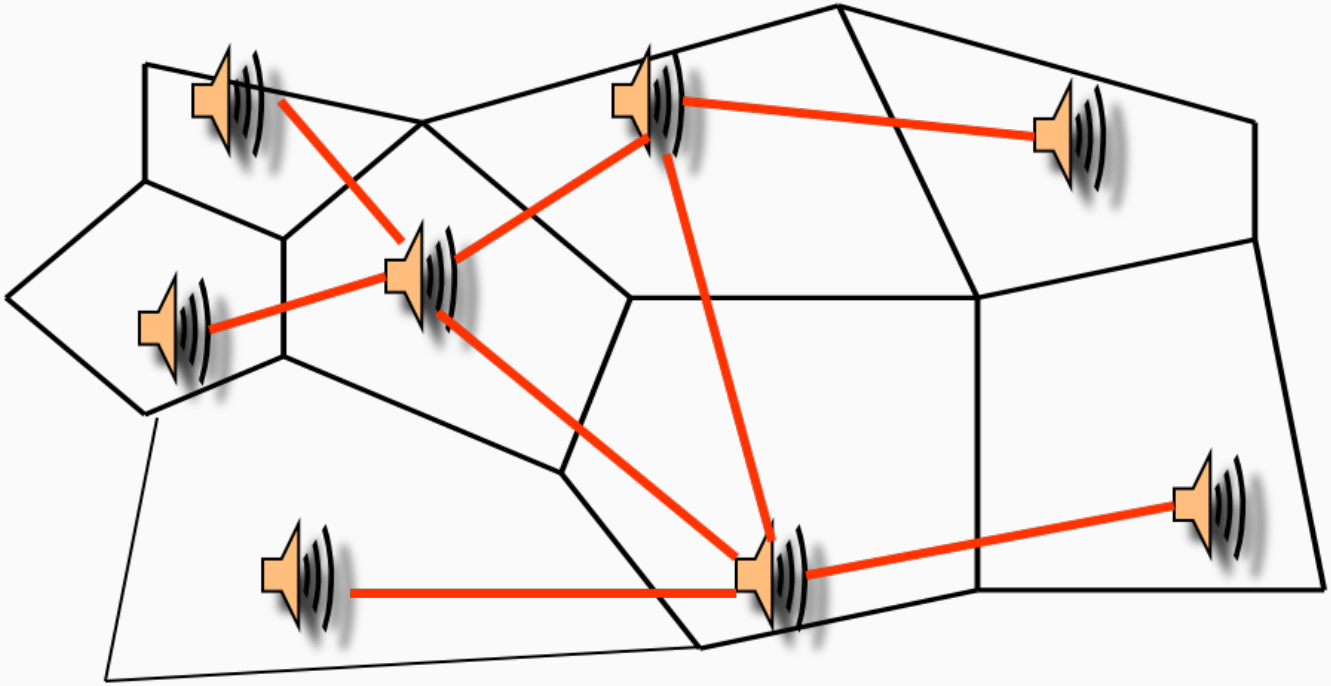
Janet

- Janet is the Joint Academic Network[1]
- All HE institutions in the UK are connected to it
- It also provides services to the research community (organizations, councils, etc.)
- The infrastructure costs are paid by JISC (Joint Information Systems Committee), part of the Higher Education Funding Councils
- JISC also provide access to eduroam in the UK

[1] https://www.jisc.ac.uk/janet

Cellular Systems

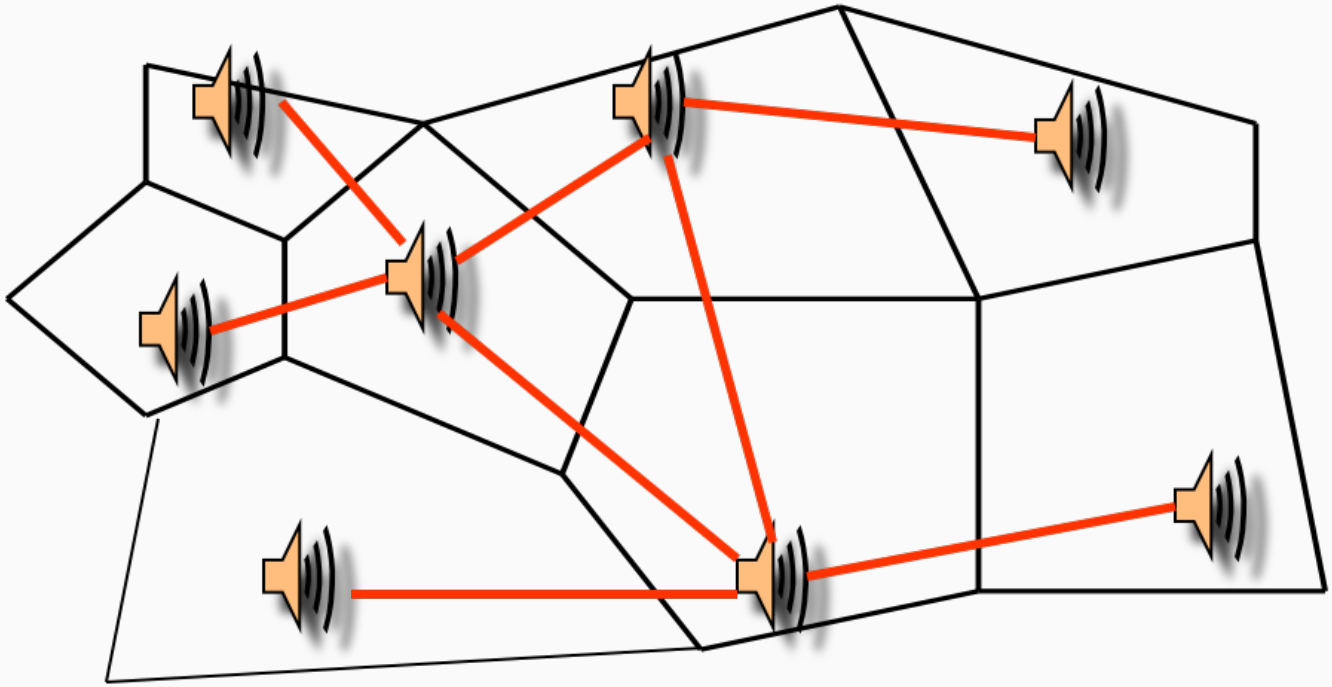
The area to be covered is divided up into cells



Each cell contains a base station

Cellular Systems

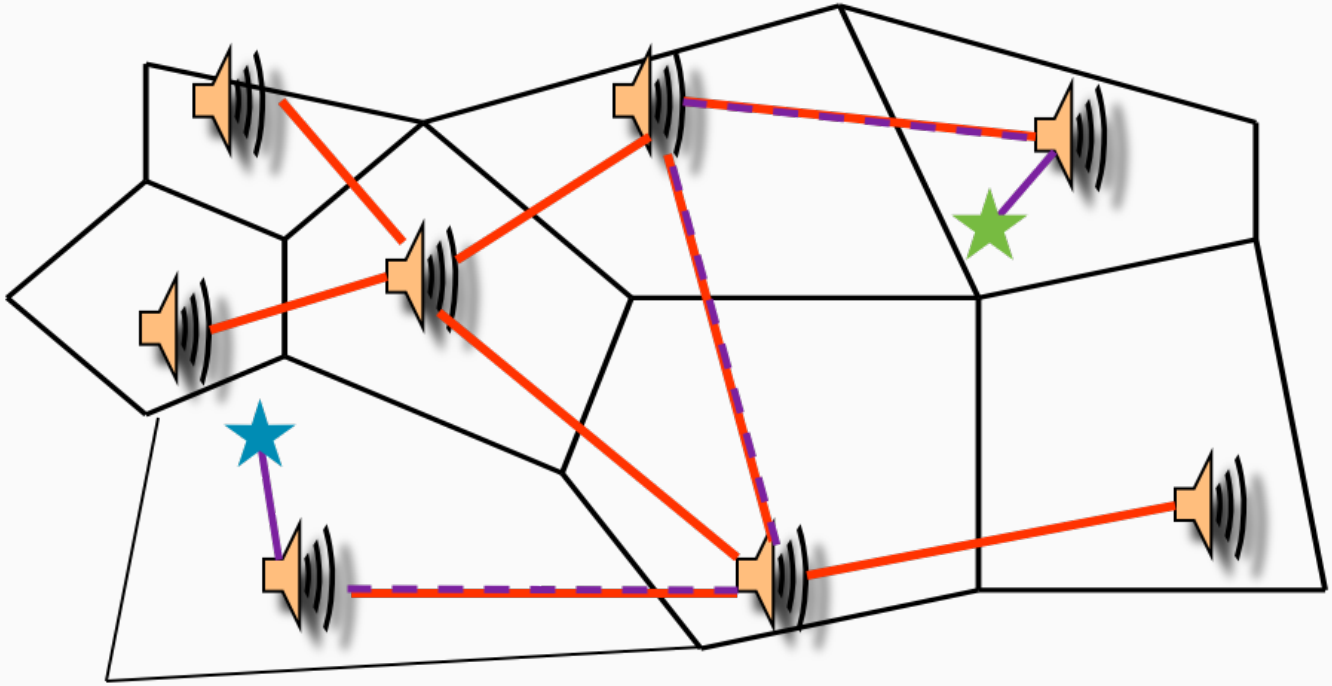
The base station contains a radio transmitter and receiver, for communicating with the mobile phones



All the base stations are connected together, usually by fibre

Routing a Call from a Mobile

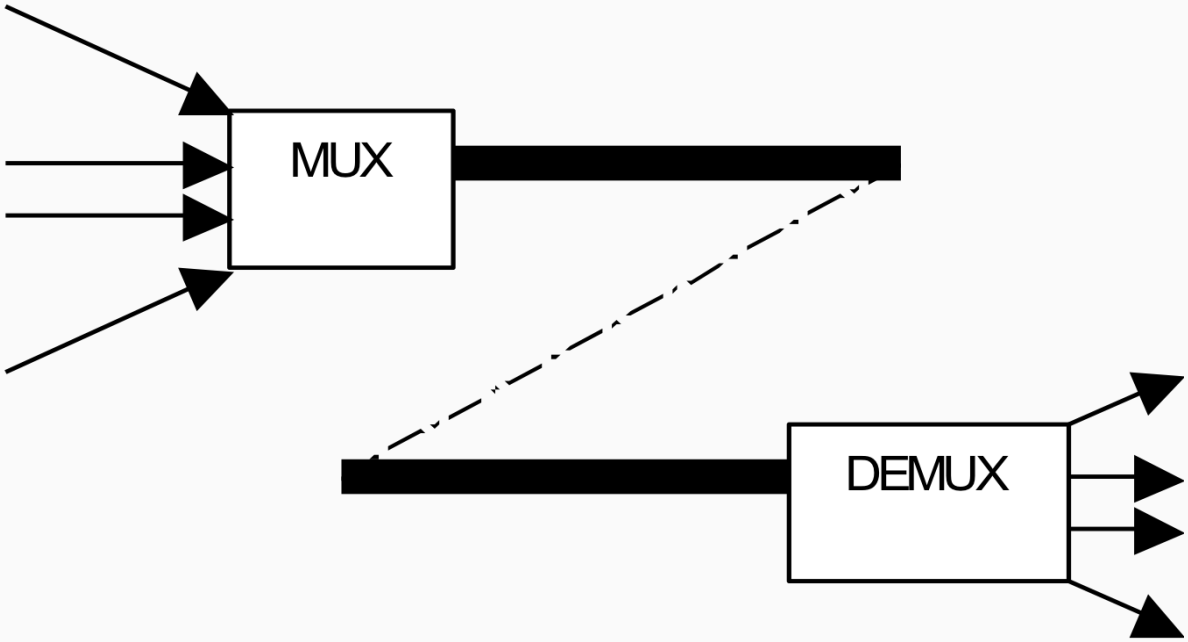
The calling mobile phone communicates with a base station using radio



The call is routed over fibre to base station of cell containing target mobile or through gateway on to PSTN if target is on a fixed line

Multiplexors

Multiplexing allows several logical channels to be transmitted across a single physical channel

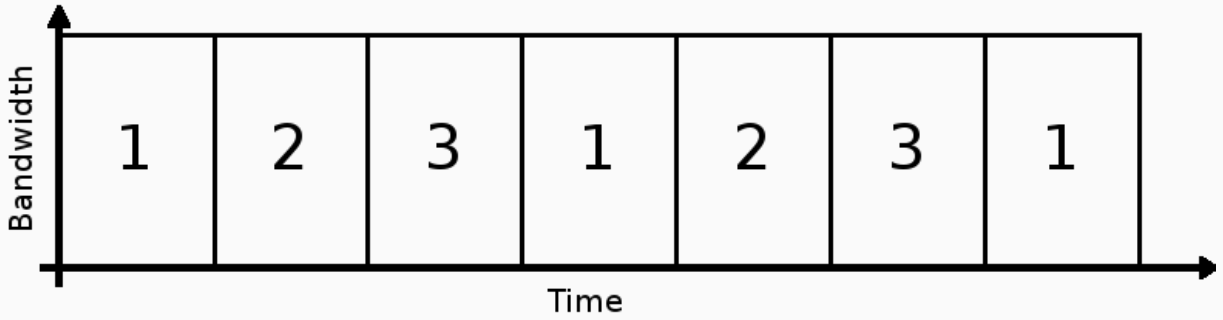


Typical use might be to multiplex 600 voice channels and 100 x 8 Mbps channels over a single microwave channel

Multiplexing

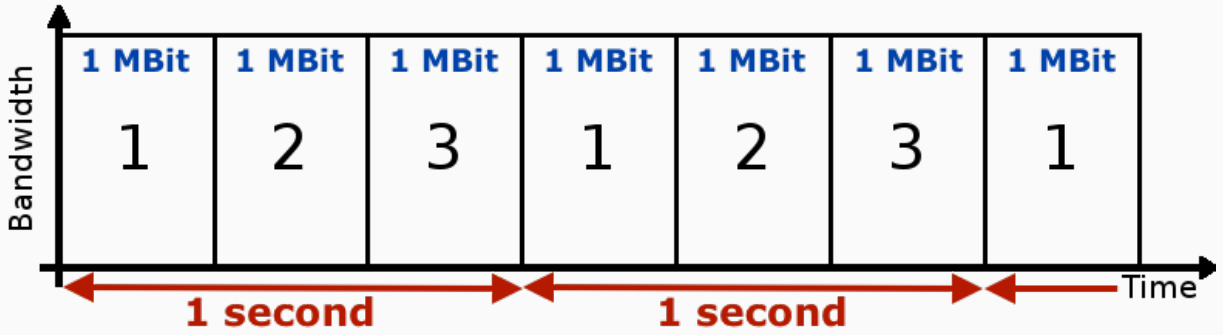
- Two main types:
  1. Time-based
     - Time Division Multiplexing (TDM)
     - Statistical Time Division Multiplexing (STDM)
  2. Frequency-based
     - Frequency Division Multiplexing (FDM)

Time Division Multiplexing



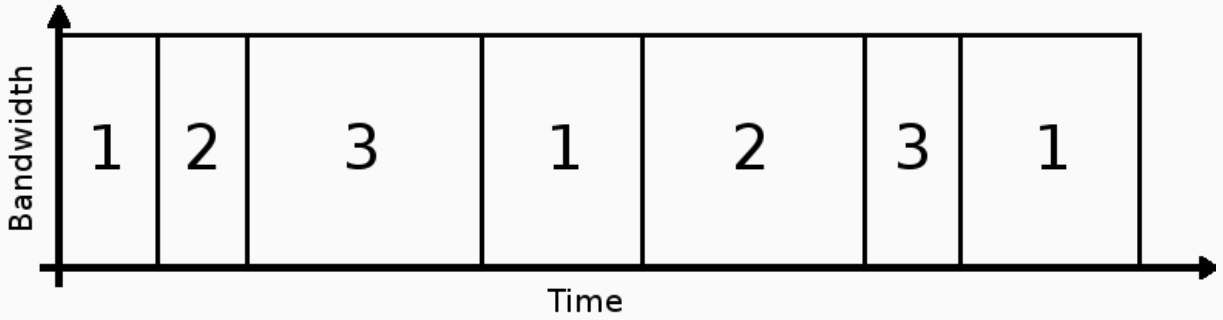
- Whole bandwidth dedicated to one logical channel for a short time slot, then to the next logical channel, and so on
- Fixed length time slots (all equal)
- Same idea as Round-Robin Scheduling
- Switches fast enough to give the illusion that signals are transmitting simultaneously

Time Division Multiplexing



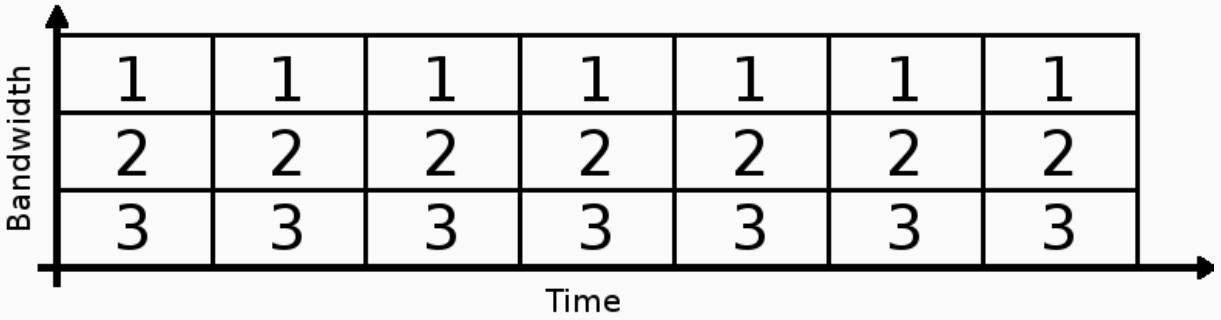
- If timeslots are 0.5 µs and your signal needs 0.51 µs, it will have to use a second slot
- Example: 3 logical channels at 1 Mbit each, with a single 3 Mbit s^{-1} physical channel to transmit everything; each channel will be transmitting 1 Mbit per second

Statistical Time Division Multiplexing



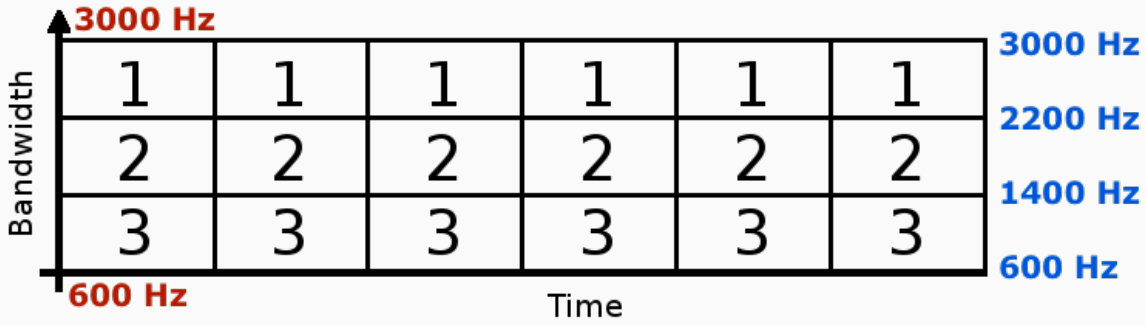
- Like time division multiplexing, but the time slots are variable and are adjusted by the multiplexor in accordance with the amount of traffic on each channel
- Time slots may be allocated based on a number of reasons: priority of the signal, amount of data to transmit (priority to more data, flexible priority)
- Time slots for individual channels are not fixed either

Frequency Division Multiplexing



- The available bandwidth is split and different slices are allocated to each channel
- So this time, channels *do* transmit simultaneously

Frequency Division Multiplexing



- Example: with an available bandwidth of 600 Hz to 3000 Hz, we might allocate
  - channel 3: 600 Hz to 1400 Hz
  - channel 2: 1400 Hz to 2200 Hz
  - channel 1: 2200 Hz to 3000 Hz

Multiplexors

Time Division Multiplexing and
Statistical Time Division Multiplexing:
every channel has *all* of the bandwidth *some* of the time

Frequency Division Multiplexing:
every channel has *some* of the bandwidth *all* of the time

Data Networks

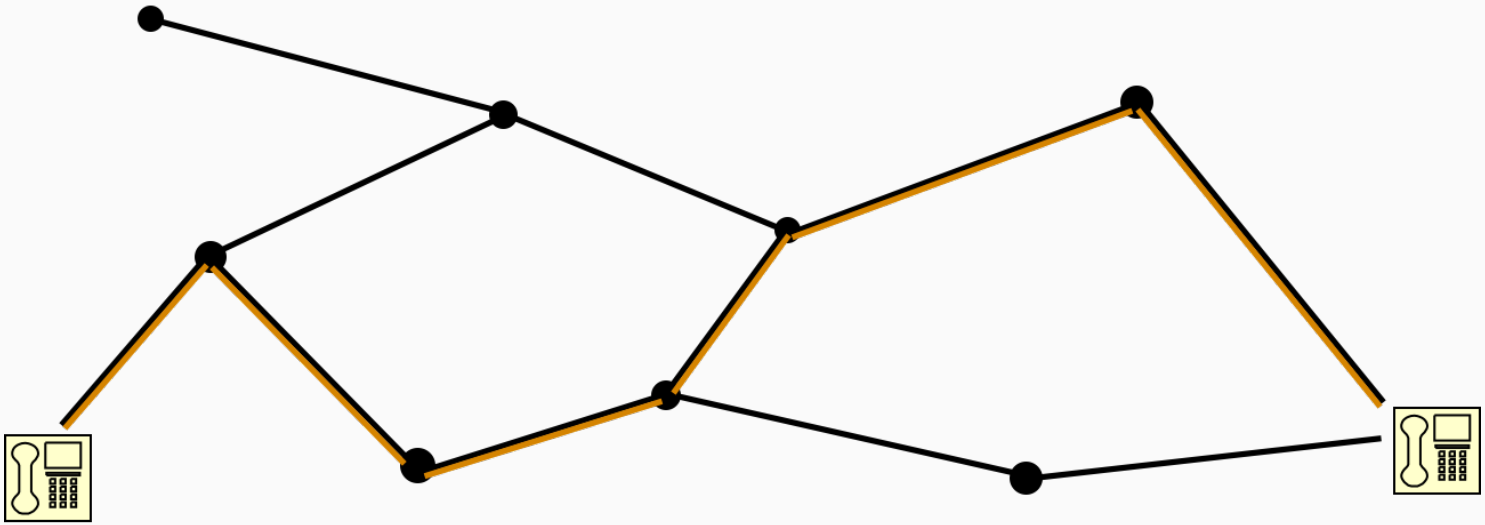
- Data networks are **designed** to carry data:
  - more bandwidth and better signal-to-noise ratio
  - which implies higher channel capacity and no need for modems
  - can use "baseband" (digital) signalling

Data vs. Voice

- Data transmission tends to be in bursts, that is, there are bursts of data separated by gaps of varying length
- Telephone signals, in contrast, are fairly uniform and continuous
- This difference has a effect on the way networks work:
  - you can't create a constant connection between two terminals for data (waste of resources)
  - you can't transmit voice in bursts (can't create, drop, every time someone speaks)

Circuit Switching

In circuit switching, a temporary but dedicated physical connection is set up for the duration of the call



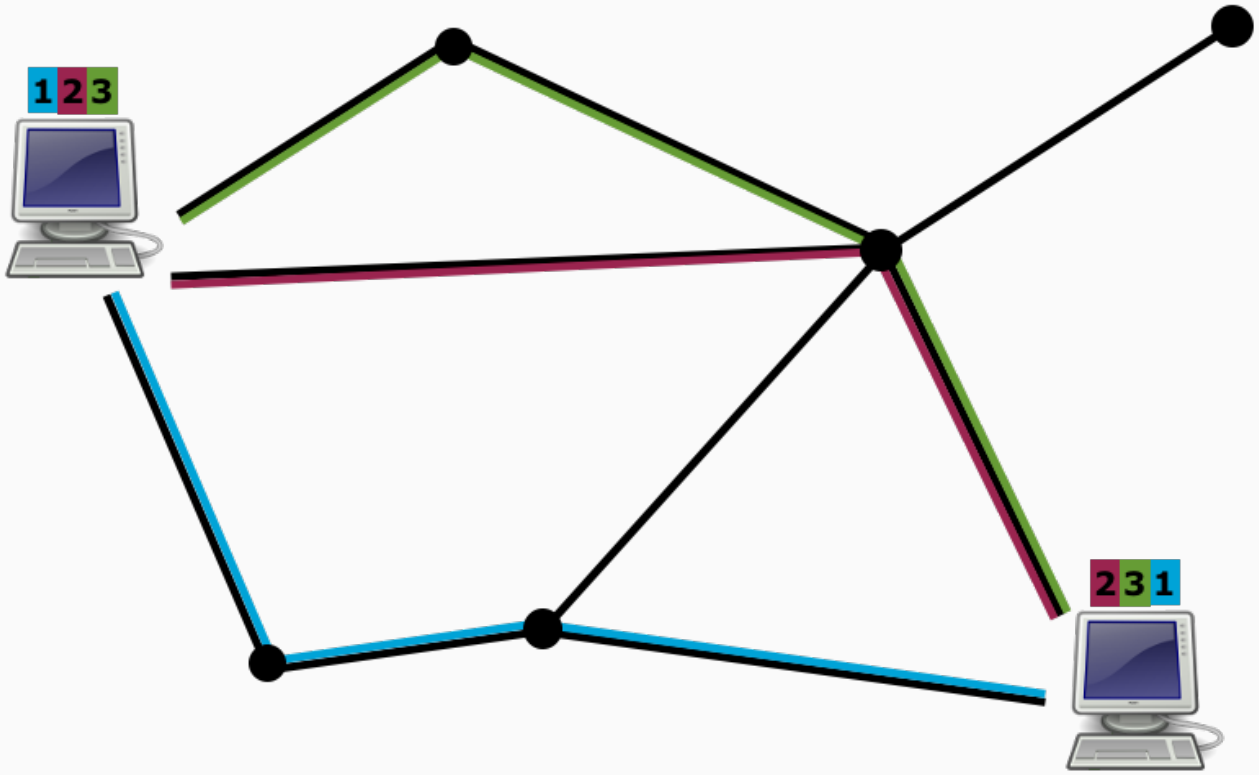
This is very suitable for audio transmission but wasteful for data communication

Packet Switching

- Data is transmitted in discrete units called packets, whose length is variable between limits fixed by the network
- Long messages are split up into a number of packets
- Each packet contains control information, including its destination address
- Packets are also known as datagrams

Datagram Approach

Packets proceed independently through the network, with each node deciding how best to route the packet



This means packets belonging to the same message may take different routes — and even arrive in the wrong order or get lost

Virtual Circuits

- What happens for something like VoIP? In some situations we need packets but they have to arrive in order!
- A single route is chosen at the start of a session
- All packets then follow the same route
- The order of the packets is preserved
- Fewer overheads than with datagram approach
  - don't have to route each packet at each node
  - don't have to check and adjust the ordering of the packets as they arrive
- Benefits from both circuit (data always in the correct order), and packet (redundancy) switching

SVC and PVC

- Switched virtual circuits (SVC) are analogous to dial-up telephone lines – set up at the start of a session and remains in existence for that session only
- Permanent virtual circuits (PVC) are set up indefinitely (or, at least, for the length of the contract)

Summary

- Introducing basic network terminology:
  - Switches, clients, and servers
  - LANs and WANs
- Multiplexing - routing several logical channels down a single physical channel:
  - Time-based (TDM, STDM) - each channel gets all of the bandwidth for some of the time
  - Frequency-based (FDM) - each channel gets some of the bandwidth for all of the time

Summary

- Switching - making connections between two terminals:
  - Circuit Switching - a dedicated circuit is made for duration of the contact
  - Packet Switching - data split into packets and sent across the network along any viable route
  - Switched Virtual Circuits - a virtual fixed-route circuit is established temporarily for packets
  - Permanent Virtual Circuits - a virtual fixed-route circuit is established permanently for packets

Next time...

Dave Price

will continue the module